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Viscosity stratification in miscible channel flow[1] KIRTI SAHU, HANG DING, PRASHANT VALLURI, OMAR MATAR, Imperial College London — The stability of two-layer miscible flows in planar channels, focusing on the neutrally-buoyant displacement of a highly viscous fluid by a less viscous one, is studied. The flow dynamics are governed by the continuity and Navier-Stokes equations coupled to a convective-diffusion equation for the concentration of the more viscous fluid through a concentration-dependent viscosity. A generalized linear stability analysis (in which both the spatial wavenumber and temporal frequency are complex) is carried out, which allows the demarcation of the boundaries between convectively and absolutely unstable flows in the space of relevant parameters: the Reynolds and Schmidt numbers, and a viscosity ratio. The flow in the linear regime delineates the presence of convective and absolute instabilities and identifies the vertical gradients of viscosity perturbations as the main destabilizing influence. Our transient numerical simulations demonstrate the development of complex dynamics in the nonlinear regime, characterized by roll-up phenomena and intense convective mixing; these become pronounced with increasing flow rate and viscosity ratio, as well as weak diffusion.

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